"COMPUTING SYSTEMS OF THE INCAS"

Software development and hardware for application to teaching
Walter Hector Gonzales Arnao
Universidad Nacional de Ingenieria

RESUMEN

The evolution of tools and gadgets designed to simplify the understanding of mathematics in all cultures has been of interest to from antiquity to the present day. there was a calculation tool called by the researchers as "Yupana" which has a similarity with ABACO Chinese origin in ancient Peru. This project has developed a Hartware and software using the calculation system of the ancient Peruvians; to be used in operational processes basic math positive integers in primary schools. Motivated by Peru indicators that place it in the last places in Latin America, in math skills. This project will have two stages in the first taken as the theoretical basis interpretations of Yupana Ing. Hugo Pereira Sanchez (researcher UNI book Quipu Project) in the development of Yupana hardware and the second part has been received the collaboration of Dr. Andrés Chirinos Rivera (UNI researcher, book Quipu Tahuantinsuyo) in the development of the Yupana Software.

Chirinos demonstrated the educational benefits that Yupana offers because it offers a visual alternative, the development of traditional numerical algorithms operation (Addition, subtraction, multiplication and division); The results demonstrated this advantage when the Yupana implemented in schools in the Peruvian Amazon. The software is in phase, experimental and make public the source code for other researchers to further develop.

It has developed hardware and software Yupana based on interpretations of Charles Wiener (1877), Henry Wassen (1931), Nicolino De Pasquale (2001), among others, which are closed source, which makes it difficult to develop based on these source codes .Palabras clave
Software, Yupana, matemática,

Key words
Software, web, matematic

1. INTRODUCTIÓN

One of the enigmas of ancient Peru, is the progress achieved in mathematics and the calculation system of the Incas. Another question are the gadgets used to perform operations, the chronicler Guaman Poma de Ayala, identifies graphically see figure 1, a table is now called Yupana as tools to perform mathematical operations based on positional values.

Chroniclers Jesuit Father Jose Acosta and Juan de Velasco, describe it as tables using grains to make calculations, with the movement of grain in different spaces, achieving operations accurately and better than Spanish arithmetic speed, the chroniclers did not document as the calculation tables was used

Fig 1: New Chronicle and Good Governance (1615)(Referencial,http://wiki.sumaqperu.com/es/Felipe_Guam%C3%A1n_Poma_de_Ayala)

It is not yet known exactly how it was used Yupana; existing debate among researchers about how it worked and this difference has generated many theories that shown in Table 1:

table 1
Interpretations of the Yupana

THEORY	BASE	YEAR
Winer	10	1876
Henry Wassén	10	1931
Emilio Mendizábal	10	1976
Carlos Radicaldi	10	1979
William G. Burns	10	1981
Nicolino de Pasquale	40	2001
Hugo Pereira	10	2007
Cinzia Florio	Aditiva	2008
Andrés Chirinos	10	2009

Each author has a different interpretation of how to use the Yupana, there is no consensus, from Wiener who reported these boards as a tool to calculate the taxes to the Inca to Andrés Chirinos who applied practically in schools of Peru. In this research project is used as a theoretical basis interpretations of Yupana Ing. Hugo Sánchez Pereira (UNI researcher, book Quipu Project) and also the theoretical interpretation of Dr. Andrés Chirinos Rivera, (book Quipu Tahuantinsuyo).

This research project aims to rescue the Yupana as a native instrument, using digital technologies so that is a cultural bridge between past and present, given the seducer who are computer applications to today's youth. It is noteworthy that the project National Engineering University, began in the laboratory of digital design FAUA UNI-FAB LAB, which was the final issue of FAB ACADEMY 2012 certification for MIT-USA, in digital design; Both projects have obtained the patent pending application for utility model Yupana hardware (File No. 2512-2012 / DIN) and registration Yupana (Docket No. 001286-2014) software INDECOPI.
This project was presented as a paper at the World Congress of digital design 2013, YOKOHAMA-JAPAN, drawing attention for its resemblance to the Abaco they use in Asia. This research is in the early stage of development and constitutes a calculation tool for children to start in the world of mathematics.

THEORETICAL

The theoretical design for hardware and software Yupana project framework, based on the interpretation of Hugo Pereira and Andrés Chirinos respectively.

All research on the Yupana, agree on the use of positional values to each space by assigning a numerical value; It is in this area the various authors are divided between those who believe they were calendars, calculation tools, gambling or architectural models, all they revolve around the numerical ratio of Yupana and speculates on how it was used.
The chronicles tell that he used quipucamayos displacing corn kernels or stones and operations could very accurately. The Yupana is closely related to these quipu knotted cords where statistical information was stored, was a sort of Excel table used by the ancient Peruvians. These anudas strings were textile products with a high level of sophistication, requiring a master for manufacturing, this due to the importance of textiles in the Andean culture that used the binary code for your designs.
No software developed in Peru, incorporating the theoretical interpretation of Ing. Hugo Pereira and Dr. Andrés Sánchez Chirinos Rivera, for this purpose has taken the license to develop this research, applying these theoretical interpretations.

2. METHODOLOGY

The development of hardware and software pose methodological problems from the point of view of technology, manufacturing of prototype hardware and source code for the software; to develop algorithms the calculation system was used as interpreted by Hugo Pereira and Andrés Chirinos.

For research purposes we use traditional and modern techniques to adapt the needs of the project, which will be explained below.

3.1 Scope of the hardware
The research used the method of approximation of the test error in a first stage proceeded to analyze the background of the prior art, and to this end identify the mathematical italiano, Nicolino De Pasquale,

developing an electronic Yupana

see figure 2.

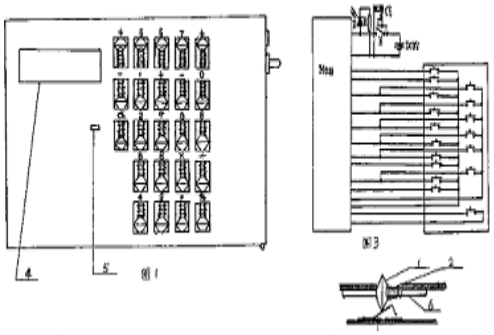
Figure 2: Electronic Yupana, built by the Italian mathematician, Nicolino De Pasquale (http://www.abovetopsecret.com/forum/thread784247/pg1)

the resemblance was studied using electronic Chinese Abaco to identify, possible analogies, given the similarity
Defined design an object that recreates one Yupana with the configuration that Guaman Poma de Ayala, pose in 1615.
One of the first problems to be solved is the part of the support (housing) of the electronic part, and the system of sensors that recognize the grains to identify the desired number.
It was tested with light sensors (fotoresistencias) miniature was discarded because once entered a grain, a number is activated and if desired add another number not recognized.
He tried to use a metal plate as a sensor to activate the number with metal parts by resistance difference. He was also a problem because the electronic components for this purpose are of dimensions that do grow much electronic Yupana.
The location of the screen allows you to view the numbers and buttons sum, subtract, off, on and rebasing also presented a design problem.

many tests location, console and spaces that make up the face of the Yupana were made.

2.1.1 Chinese Background

Currently, there are digital computers that simulate operations with Chinese abacuses, as the closest prior art disclosed in Chinese patent CN86204554 (A1) publication dated 12/17/1986; ZHANG JIUGUI; "Electronic calculator movable type accounts." This patent relates to an electronic calculator provided with moving accounts to simulate the use of a Chinese abacus, calculator facilitates learning operations of addition and subtraction; the calculator is provided with an electronic circuit (microprocessor), a display screen (display) and accounts arranged similarly to the abacus and to move activate an electrical switch (See Fig. 3) to perform operations instead of pressing a keyboard.



see figure 3: The scheme of operation of the electronic Abaco shown, antecedent

However, Chinese abacus operation is very different operation Yupana; Chinese abacus in the fields of numbers are also divided into units, tens, hundreds, and so on, during operation of the Chinese abacus moving the balls to perform operations; whereas, in Yupana fields are formed in cavities within which the beads or balls are placed during operation. Therefore, to simulate the operation of Yupana is necessary to place the accounts to display numbers; also with Yupana operations can be performed in different number bases such as base

5, 10, 40; while the Chinese abacus the base used is only the base 10. To simulate the Yupana in the proposed solution a digital calculator where, when registering accounts or balls a sensor is activated, or an alternative solution is used when no It requires the use of beads or balls, upon actuation of the sensor associated with this LED lights up.

2.1.1 Descriptión of the Yupana hardware

This Yupana is susceptible of embodiment in many different forms, the drawings and description detail a preferred embodiment of the invention. It should be understood that the drawings and description are to be considered as an exemplification of the principles of the invention and are not intended to limit the broad aspects of the invention to the embodiments illustrated.
Then, in relation to Figures 4 and 5 a digital calculator based on Yupana, the same described comprising: a printed circuit (1) where the mounting of electronic components, such as is performed: Then, in connection with Figures 4 and 5 a digital calculator based on Yupana, thereof comprising described sensors (2), for reasons of clarity it will be numbered only one sensor, the microprocessor (3), switches (4, 4 ', 4 "), integrated circuits (5) and a screen (6) display LCD; also comprises a cover (7) clear acrylic.
As you can see the board is divided into three rows (U, D, C) of four fields (a, b, cd) each, in each field a sensor associated with the number of units used in the Yupana placed ; a sensor for the first field, two sensors for the second field, three sensors for the third field (which is the sum of the above fields) and finally five sensors for the fourth field (which also is the sum of the above fields); likewise the fields for the tens and hundreds are divided.
a switch is also used to turn the calculator or restart an operation, a switch to change base number and another to adjust the brightness of the screen.
In an alternative embodiment, each sensor is associated with an LED (8) adjacent the same used to display the drive lighting; thus it is not necessary to use beads, balls or balls provided a pin to display the numbers used in the operation.

Although the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various equivalent changes can be made, and can be substituted without departing from the broader aspects of the invention.
Accordingly, it is intended that the foregoing detailed description be regarded as illustrative rather than limiting, and it is understood that the following claims are, including all equivalents, that are intended to define the scope of this yupana.

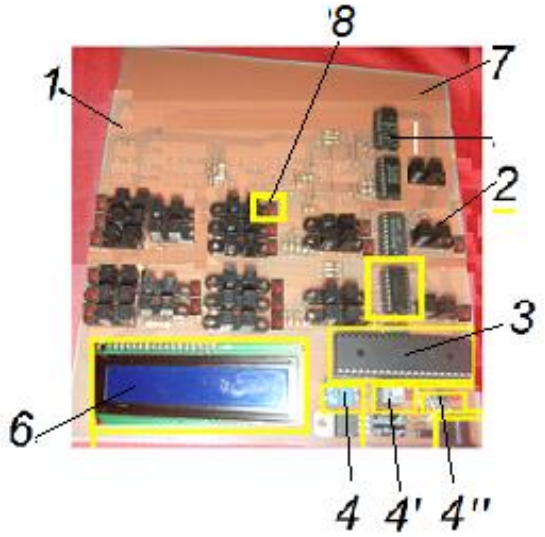
figure 4: shows the console Yupana design.

figure 5: shows the console design Yupana

3.2 Scope Software

To carry out software development yupana was taken as antecente, software-TkYupana is a simple program that shows some theories about Yupana, based on the positional number system base 10. See Figure 6.

Figure 6: Tk-yupana the system has on the main screen a video tutorial in PDF http://www.kunturweb.tk



https://www.youtube.com/watch?feature=player_embedded&v=gX4ElP-KFQM
http://kunturweb.altervista.org/tk-yupana/doc/tk-yupana-ES.pdf

Because the source code is closed, has built a table with the relevant technical specifications see table 2

table 2 Program Web: Tk-Yupana r	
Thecnology a used	Gnu-Linux (o Mindoms)
Autor	Kunturweb
versión original:URL	0.7- **7/2/2013** http://kunturweb.altervista.org/pag/en/tk-yupana.html
consola	El centro de interés de la pantalla, que recrea la Yupana, es la consola, que permite realizar las operaciones
prestaciones	puede recrear las diversas interpretaciones de la yupana
aplicatión	Es un SOFTWARE, que emula los diversos métodos de cálculo de la yupana
Code	cerrado

Table 2: This table presents the technical characteristics of software history

3.2.1 Methodology quantitative

This quantitative methodology is based on the development of software engineering framework is used to structure, plan and control the process of development in information systems.
For the development of software in this research the model Top-down ("top-down") was used; since each project has its particularity, this model has been adapted following the following steps

I. Define the project. II. Analysis of context. III. Definition of requirements. IV. Preliminary design. V. Detailed design.

3.2.2 Qualitative Methodology
The draft qualitative methodology is based on web interface user graphical environment. Usually user actions are performed by manipulating the graphical environment web (form).
The web graphical environment, everything is visual (design) that gives us the best of the software and is related to the habits of Internet users. For this project has been taken into account empirically, web graphics environments that resemble the proposal and focus on the impact of users according to our sensibilities.
For further research will require a specialized study habits of web users graphical environment, so that the software is in effect on users and the life cycle is longer.
3.3 Calculation method according Hugo Pereira and Andres Chirino
3. PROBLEM
In the initial approach to the problem points are considered.

4. FINAL RESULT

The end result can be displayed on the website, which is in the stage of debugging, ie is correcting errors and is summarized in Table 3.

TABLE 3 Program: SPREADSHEET FOR CHILDREN, BASED ON MATHEMATICS OF THE INCAS (Yupana)	
thecnology	Visual Basic
Original version:	2013-03-15 versión 1.0
tutorial	https://www.youtube.com/watch?v=CGNzzxlLrQo

Code	`Imports System`
	`Imports System.Drawing`
	`Imports System.Windows.Forms`
	`Imports System.Math`
	
	`Public Class Form1`
	
	`  Dim A As Decimal = 0.0`
	`  Dim B As Decimal = 0.0`
	`  Dim C As Decimal = 0.0`
	`  Dim temp As Decimal = 0.0`
	`  Dim um As Integer = 0`
	`  Dim ce As Integer = 0`

	Dim de As Integer = 0 Dim un As Integer = 0 Dim dc As Integer = 0 Dim Op As Boolean = False Dim oper As Char = ""
Prestaciones	It allows you to display a graph to display the operation simulating Quipus in separate columns
Aplicación	You can do basic math, positional values This table is the main panel display allows the user to enter data edit mathematical operation

Table 3: you can see the technical feature of the software

This software called, SPREADSHEET FOR CHILDREN, BASED ON MATHEMATICS OF THE INCAS (Yupana), software used as an educational tool in primary school is a teaching resource that facilitates mathematical calculation. This software developed in Visual Basic. This is version 1.0 of March 15, 2013

This application can be viewed from a PC or mobile devices where you can run the application.

5.1 BASIC INFORMATION

5.1.1 ENTRY FORMS

THE SPREADSHEET FOR CHILDREN, BASED ON MATHEMATICS OF THE INCAS (Yupana), is an instrument that facilitates the teaching of mathematics to children; because it allows you to display, edit checking operations that emulate the mathematical operations of the Incas (the Yupana). Algorithmic operational modules are designed for easy and friendly way to perform mathematical operations.

The table presents a main panel with a dialog box that allows numeric entries pecking with the mouse; if touchscreenen screen that facilitate the entry of numbers biting the finger and are designed very convenient way to interact with the application does not have.
The table consists of the following modules:

• RESULTS IN THE FORM OF GRAPHICS
• Operations Console
• Type dialog box DISPLAY
• TABLE OF VALUES POSITIONAL

5.1.2 PRINT MODE

You can catch the image with the PRTSC key, and exporting to Word as jpg image, to have a record of work

5.1.3 AS THE MEETING ENDS

the sale is closed, biting the field where it appears reset

5.1.4 HOW TO ENTER THE SYSTEM

The table is a system that has free access with built installer and does not require user or password to access the application see Figure 7 and 8

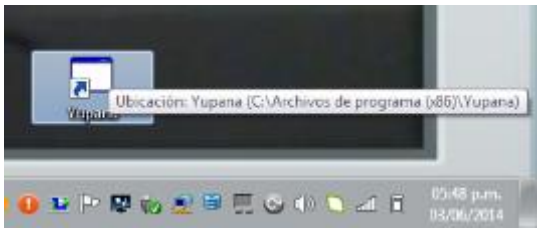


Figure 7: icon representing the application that must click to enter

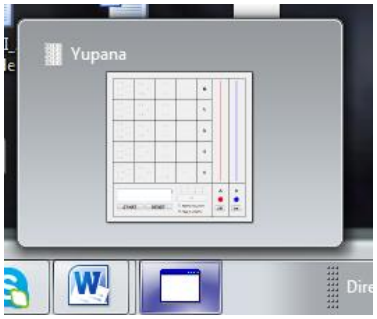


Figure 8: the icon at the lower end, represents the application in use.

5.1.5 HOW TO START THE APPLICATION

how to add application used; similarly all operations (subtraction, multiplication and division) are performed and are as follows:

1. ENTERING THE APPLICATION

Calculation table is a system that has a data entry window that this simulates a console window calculation, see Figure 9, 10 and 11:

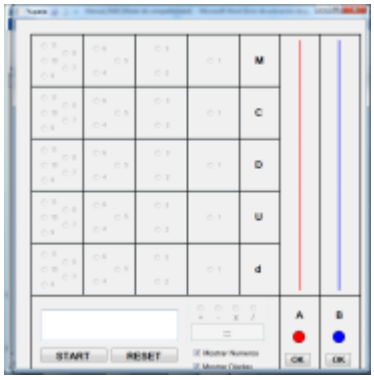


Figure 9: START is pressed, activating the whole system

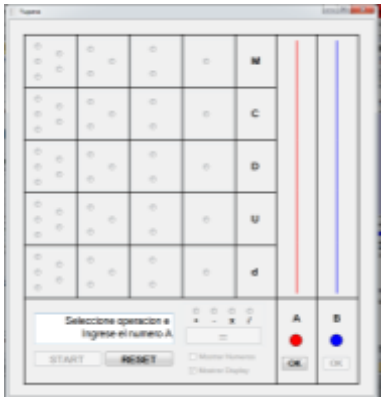


Figure 10: to raise the degree of difficulty has an alternative to disable the positional numbers be hidden at the time of the operation, to develop children's memory

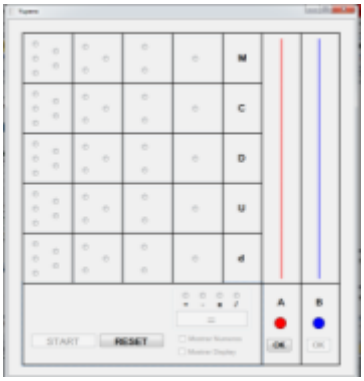


Figure 11: further raising the level of difficulty, you can disable the display that displays the result.

1. Enter the application that contains the calculator; the numbers displayed on each space with respective positional values, which allow you to select the desired number, see Figure 6:

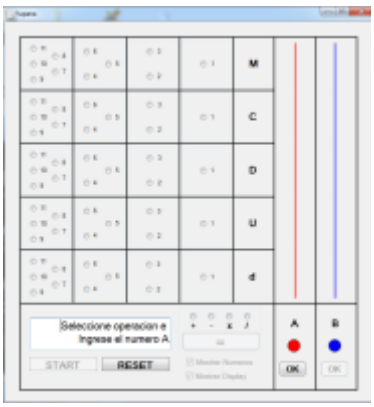


Figure 6: Entering the application after turning START, the console tells you in a friendly way to enter the first number you want for the operation

2. The first number is entered, see figure 7.

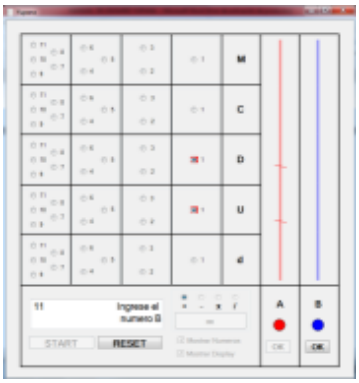


Figure 7: The number 11 is inserted for example

3. Click on the sum, see Figure 8.

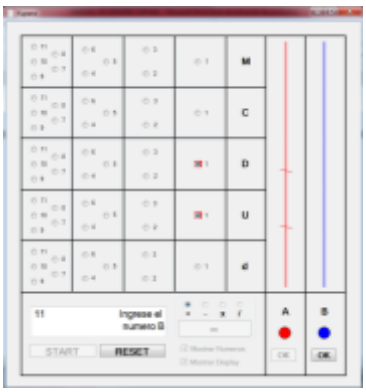


Figure 8: activated the plus key, then enter ano

ther number.

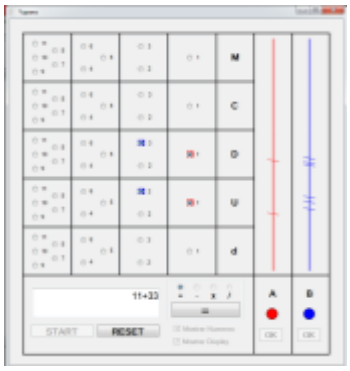
4. The second number is entered.
5. 

Figure 8: on the console the other number for this case is introduced 33

6. Click on the same key, see Figure 9

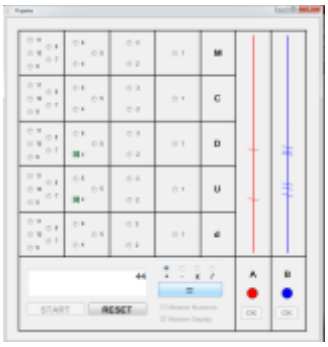


Figure 9: after activating the same key (=), you can see the result, complementarily is displayed alongside a recreation of a quipu, on the right side of the console.

8. conclusiones

8.1 The system has technical deficiencies, sensors, microcontrollers, and lack of suitable components that can be designed,

8.2 The aesthetic theme of the presentation as a final product, requires the development of a market study, to have acceptance and can be offered.

8.3 The programming software requires a multidisciplinary team capable of

integrating engineering contribution and specialties such as education, social anthropology, to customize the Yupana for each region of Peru.

8.4 Lack of a sector the academic community and some authorities of the potential of this mathematical system that prevent the implantation of use in Peruvian schools.

8.5 undervaluation of Andean culture and its contribution to the mathematical sciences for application

8.6 overvaluation of Western culture in mathematical sciences, which prevent recognize the value of this contribution

8.7 Reaching a hardware and software Yupana with quality and performance that is accepted by the market, it requires improvement and investment for now the research institutions are unwilling to bet.

8.8 When you start the research project Yupana, no institution, had the mechanisms that would be admitted as research within the academic formality, only when results were achieved with patents is that this item was admitted

8.9 China is a good example of repricing of Abaco Abaco having developed its diffusion and industrialization levels for the consumption of their ancestral culture.

8.10 one of the main dangers of yupana project is that the concept is distorcione yupana.

8.11 the idea that makes the mathematical operation to solve simple and complex calculations, lose its essence by the glare of technology.

8.12 that the connection with nature is lost, the materiality of abstraction.

8.13 The items to electronic Yupana object, software, web distance themselves from the essence of Yupana andiana are additions.

9. DISCUSSION EVALUATION

9.1 The Yupana project is the valorisation, the system for calculating the INCA culture, using the latest technology.

9.2 This is a global project that includes several stages, the first is the development and improvement of the Yupana ELECTRONICS; in the second stage it is made the Yupana SOFTWARE is an application for web page so that young people can learn this system of calculation Inca, in a playful way through the internet.

9.3 The cultural contributions (art, medicine, agriculture, etc.) of Andean society of Peru in all areas of human development have been forgotten by Western training we received in Peruvian education. The mathematics are no exception in this sense this project is a tribute to ing. PEREIRA Hugo Sanchez graduated from UNI, which investigated the quipu and Yupana, demonstrating a love of Peruvian culture. His works were published posthumously by CONCYTEC, 2011; In this context I become aware, of his work by the ceramic object, the Yupana, given my teaching as a professor of Ceramics, Experimental Looms in FAUA-UNI.

9.4Habiendo yupanas developed different types of clay and acrylic, in the course I teach and laboratory digital design FAUA-uni, I am contacting dr. Andrés CHIRINOS RIVERA (picture 3), who had experience with yupanas wood that develops in an intercultural project in the Peruvian jungle, and with his experience I contribute in improving the Yupana SOFTWARE, incorporating the teaching of teaching children with adds the methods of the Incas.

9.5 was received for perfecting this software, support the arch. LUIS

SOLDEVILLA (Head of UNI admissions office) and arch. LUIS HAIR (Dean FAUA-UNI).
9.6 In this project teachers called authorities UNI students with a common interest, rebuild the mathematics of the Incas for new generations, ING. HUGO PEREIRA start at the UNI, the work of everyone who participated in this project was ad honoren and even contributed financially, as ing. Luis Jaramillo

9.7 This project aims to create a bridge between the past and the future, bringing the system for calculating the Incas young people with the technological resources of modernity, so that new generations know the cultural contributions sciences mathematics of Peruvian society to world. Since these mathematical systems maintained an administrative organization in the Inca state.

9.8 This project with more than 15 preliminary prototypes (Figure 4) is self-financed because of the research institutes do not provide for research in this area. The development of Andean technologies originating in the field of mathematical sciences, is not a priority for the traditional academic system

8. REFERENCES

Book1. Julia Walter Herrmann, I., "FabLab of machines, maquers and Inventors", first edition, editorial Cultural and Media Sudies. Deutsche 2013. ISBN: 978-3-8376-2382-6

3. Bas Van Abel, Lucas Evers, Roel Klaassen, Peter Troxler, "Open Design Now", second printing. BIS publishing edition, USA San Francisco 2011. ISBN: 978-90-6369-259-9
4. Magazine article

3.Gonzales Arnao, Walter H., "An approach to the culture of industrial design in Peru". Teacher Magazine, No. 8, pp20-23, Peru 2009.

web information

4http://www.amigolatino.de/indigena/delusion_dialectica_11_10_09.pdf5. http://156.35.151.9/~smi/5tm/10trabajos-practicos/1/Memoria.pdf

6. http://www.khronos.org/files/opengl41-quick-reference-card.pdf

7.http://www.khronos.org/webgl/
8. http://khronos.org/webgl/wiki/Main_Page
9.http://worldspace.berlios.de/fase1/index.html

10.http://www.scribd.com/doc/31291543/OpenGL-Basico
11. ACOSTA José De, Historia Natural y Moral de las Indias, 1590 http://to.ly/jdJO

12. Libro VI cap XVIII – De los memoriales y cuentas que usaron los Indios del Perú http://to.ly/jdJW
13. http://es.scribd.com/doc/36501843/Yupana-Digital
14http://books.google.com.pe/books?id=TmbajGgliYYC&pg=PA296&lpg=PA296&dq=estudios+sobre+la+yupana&source=bl&ots=ohT_Nr8bU2&sig=saCutxmuA0zLHjSlvUcro1xdUQM&hl=es-419&sa=X&ei=XRkKU-HSLPSgsASOqYHADA&ved=0CDMQ6AEwAQ#v=onepage&q&f=false

15http://www.monografias.com/trabajos65/charles-wiener/charles-wiener3.shtml#xsistcalcincas

16. http://cursa.ihmc.us/rid=1J2NH8QTM-2912G6-PZ5/yupana_como_herramienta_pedagogica.pdf

17.http://cienciatecnologiainnovacion.blogspot.com/2011/09/aporte-del-ing-hugo-pereyra-al.html

18. http://www.monografias.com/trabajos-pdf2/acerca-yupana-calendarica/acerca-yupana-calendarica.pdf

19.http://kunturweb.altervista.org/tk-yupana/doc/tk-yupana-ES.pdf

20.http://www.abovetopsecret.com/forum/thread784247/pg1